ISSN 0704-3716

Canadian Translation of Fisheries and Aquatic Sciences

No. 5451

Alternative peeling method for shrimps: Kroborg peeling machine and peeling of raw shrimps

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Original title: Alternativ pilling av reker: Kronborg pillemaskin og pilling av ra reker

In: Fiskeriteknologisk Forskningsinstitutt. Rapport U 47, 1988, 49 p.

Original language: Norwegian

Available from:
Canada Institute for Scientific and Technical Information
National Research Council
Ottawa, Ontario, Canada K1A 0S2

1989

52 typescript pages

Secretary of State / Secrétariat d'État

90-00581/

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

TRANSLATION BUREAU BUREAU DES TRADUCTIONS

LIBRARY IDENTIFICATION – FICHE SIGNALÉTIQUE

Translated from - Traduction de	Norwegian	Into - En	English

Author - Auteur

Hallur VIGGOSSON

Title in English or French - Titre anglais ou français

ALTERNATIVE PEELING METHOD FOR SHRIMPS

Kronborg peeling machine and peeling of raw shrimps

Title in foreign language (Transliterate foreign characters)
Titre en langue étrangère (Transcrire en caractères romains)

ALTERNATIV PILLING AV REKER

Kronborg pillemaskin og pilling av rå reker

Reference in foreign language (Name of book or publication) in full, transliterate foreign characters.
Référence en langue étrangère (Nom du livre ou publication), au complet, transcrire en caractères romains.

FISKERITEKNOLOGISK FORSKNINGSINSTITUTT

RAPPORT U 47

Tromsø, mai 1988

Reference in English or French - Référence en anglais ou français

INSTITUTE OF FISHERY TECHNOLOGY RESEARCH
REPORT U 47
Tromsø, May 1988

Publisher - Éditeur	DATE OF PUBLICATION / DATE DE PUBLICATION			Page Numbers in original / Numéros des pages dans l'original
FISKERITEKNOLOGISK FORSKNINGSINSTITUTT	Year / Année	Volume	Issue No. / Numéro	0 - 50
Place of Publication / Lieu de publication: Tromsø, Norway	24 May 1988		Report No U 47	Number of typed pages / Nombre de pages dactylographiées: 1 - 50

Requesting Department / Ministère-Client: DFO

Translation Bureau No. / Notre dossier nº: LSM-9-00026

Branch or Division / Direction ou Division: Scientific Publications

Translator (Initials) / Traducteur (Initiales): A.M.G.

Person requesting / Demandé par: Heather Cameron

Your Number / Votre dossier nº: 3511514

Date of Request / Date de la demande: 31 March 1989

Canada

SEC 5-111 (84-10)

Department of the Secretary of State of Canada | Secrétariat d'État du Canada

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

TRANSLATION BUREAU | BUREAU DES TRADUCTIONS

Client's No.–Nº du client	Department – Ministère	Division/Branch – Division/Direction	City – Ville
3511514	DFO	Scientific Publications	Ottawa
Bureau No.–Nº du bureau	**Language – Langue**	**Translator (Initials) – Traducteur (Initiales)**	
LSM-9-00026	Norwegian	A.M.G.	15 May 1989

FISKERITEKNOLOGISK FORSKNINGSINSTITUTT
INSTITUTE OF FISHERY TECHNOLOGY RESEARCH

FTFI REPORT NO. U 47.

ALTERNATVE PEELING METHOD FOR SHRIMP.
KRONBORG PEELING MACHINE AND PEELING OF RAW SHRIMP.

BY: HALLUR VIGGOSSON.
TROMSØ, NORWAY, MAY 1988:49 PAGES.

ALTERNATIV PILLING AV REKER

Av
Hallur Viggosson U 47

Tromsø, mai 1988

ftfi **RESEARCH INSTITUTE OF FISHERIES TECHNOLOGY**

VESSEL SECTION	HEAD OFFICE	FISHING SECTION
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	University Campus, Breivika	
	P.O.B. 677	
	9001 Tromsø	

Report No: U 47

Accessibility: OPEN

REPORT

TITLE OF REPORT:	ALTERNATIVE PEELING METHOD FOR SHRIMPS (PRAWNS) Kronborg Peeling Machine and Peeling of Raw Shrimps (Prawns)	Date: 24 May 1988 No of pages and appendices: 49
OFFICER IN CHARGE/AUTHOR:	Hallur Viggosson	Authorized Signature: Dagfinn Malnes
SECTION	PROCESSING	Project No: 3204
CLIENT	NFFR	Client's reference No: 663.10

ABSTRACT

Thawed-out shrimps were peeled raw with a conventional peeling machine. Curing and peeling conditions were varied. The peeling yield varied between 41.0 and 51.8%.

It will be possible to market raw peeled shrimps unprocessed in a frozen condition (preferably frozen singly) or dipped in batter ready for deepfrying.

The Kronborg peeling machine was evaluated with various raw materials. The tests showed that the machine could peel shrimps cooked at sea with good results. Fresh ice-covered shrimps and thawed shrimps frozen at sea were, however, a poor raw material. The Kronborg peeling machine is therefore suitable for use on vessels.

3 INDEX WORDS

Shrimp peeling
Raw shrimps
Kronborg

See translator's notes for interpretation of terminology used in Norwegian text. page 50

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

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SUMMARY

Thawed shrimps were peeled raw with a conventional peeling machine. The peeling yield varied between 41.0 and 51.8%, excluding glazing. Shrimps cured in fresh water with 35 o/oo* sea salt added produced the highest peeling yield while at the same time the degree of clean peeling was satisfactory for industrial production.

The degree of clean peeling can be increased by using sandblasted "insert rollers", rubber coverings on the bottom rollers in the lowest roller section, an internally rubber-covered "cleaner" and a shell separator of the roller type. With this type of equipment an 100% degree of clean peeling and 41.4% peeling yield was achieved.

The peeling yield in the tests is not directly comparable with the peeling yield in industrial production since losses occur only in the peeling process, and not before and after it. The peeling yield in the industrial peeling of raw shrimps can be realistically estimated to be 40-45%, including glazing.

Cooking of raw peeled shrimps results in a large cooking loss and in a product which is not very attractive. Raw peeled shrimps (preferably frozen singly) can be marketed unprocessed in a frozen condition or dipped in batter ready for deep-frying.

The Kronborg peeling machine was evaluated with various raw materials. The tests showed that the machine peeled shrimps cooked at sea (cooked immediately after catching) with good results. Fresh ice-covered shrimps (landed raw) and thawed shrimps frozen at sea were, however, a poorly suited raw material. The Kronborg peeling machine is therefore best suited for use on vessels.

* o/oo = parts per mil

Page 4. 1. INTRODUCTION

1.1 Objective

The objective of this work was to investigate possibilities for alternative peeling methods for shrimps. Two alternative peeling methods were to be evaluated:

1. Peeling of raw shrimps with a conventional peeling machine.
2. Peeling of shrimps with a Kronborg peeling machine.

1.2 Background

When compared with filleting plants, the shrimp plants have a very small spectrum of products. It was therefore desirable to investigate whether alternative products could be manufactured with deepwater shrimp [prawn] (Pandalus borealis), and whether this might result in increased profitability.

The principle, on which the peeling machines used in Norway are based, was developed before World War II in the U.S.A. Originally the machines were developed to peel raw shrimps. Subsequently a cooking unit was manufactured for the peeling machine. To-day there are three predominant makes of roller peeling machines on the market: Laitram and Skrmetta made in the U.S. and Vega which is manufactured in Norway. All types of machines are based on friction peeling with rotating rollers.

Peeling of raw shrimps is to-day a common manufacturing method in the U.S; it was therefore of interest to become acquainted with this technique and to examine whether it is suitable for peeling deepwater shrimp.

Several years ago a new type of peeling machine was designed. Two Danish collaborating partners started this development work: Jydsk (Jutland) Technological Institute and Kronborg Ltd. The principle of the machine is based on the following: Rapid heating with formation of small air bubbles under the shell and feeding into a vacuum chamber where the air bubbles expand and blast the shell from the shrimp meat. The reduction in pressure produces at the same time an acceleration of the shrimps so that the shell is knocked from the

Page 5 shrimp muscle when these hit the inclined plate.

Kronborg has since continued the development of the machine, and in the fall of 1986 FTFI (Research Institute of Fisheries Technology) initiated cooperation with that company. The objective of the cooperation was to evaluate the Kronborg peeling machine with industrial raw material (raw material for manual peeling and machine peeling plants).

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2. MATERIAL AND METHODS FOR PEELING RAW SHRIMPS

Raw shrimps were peeled with a Skrmetta peeling machine. To begin with, a peeling machine was operated which is in daily use for peeling cooked shrimps. Cooking of shrimps results in shrinking of the muscle away from the shell and in weakening of the bonds between muscle and shell. It could therefore be expected that raw shrimps are more difficult to peel than cooked shrimps, and it has consequently been considered important to find a pretreatment (curing) for shrimps which would improve the degree of clean peeling.

In the following series raw shrimps were peeled with a peeling machine specially equipped for peeling raw shrimps. This machine was located in a shrimp plant in New Orleans. In addition the Americans use a different cleaning process following the peeling machine than is used in Norway. This cleaning process was also evaluated.

2.1 PEELING WITH A PEELING MACHINE EQUIPPED FOR PEELING COOKED SHRIMPS

2.1.1 Raw material, thawing and grading according to size

The shrimps were caught in the Barents Sea on May 17-19, 1987, by the shrimp trawler Vibeke Helen; they were frozen in 10 cm thick blocks in a vertical plate freezer. The average block weight was 24.8 kg. The size distribution among the blocks is listed in table 1.

The blocks of shrimps were stored in a freezing plant at -30°C prior to thawing. The tests were carried out during the period 18 June - 28 July, 1987.

In the tests a small scale thawing apparatus was used which was built by FTFI (Malnes et al., 1987). The temperature of the thawing-out water was maintained constant at 15°C.

Page 7

Following thawing the shrimps were graded according to size, using a Kronborg grader (type Panda 2004). The largest shrimps were separated and not used in the tests. Table 1 shows the size distribution for unsorted raw material and for the size group which was used in the tests.

TABLE 1. Size distribution of the raw material used in the tests.

GROUP	UNSORTED	AFTER SORTING
Over 7.5 cm	40.7%	35.7%
6.0 - 7.5%	34.7%	35.0%
Under 6.0%	4.0%	5.7%
Damaged	20.6%	23.6%

Damaged shrimps are defined as shrimps with a broken muscle and/or without a head. Sorting increased the share of damaged shrimps by 3.0%. It is noted that most of the damaged shrimps were without a head.

2.1.2 Curing

The shrimps were cured in various ways to establish a curing procedure which produced a high peeling yield and degree of clean peeling, and which also delivered a good quality. Seven tests were carried out, and in all of them covering with ice in crates was used as a control. Ten kg shrimps were placed in a 66 litre shrimp crate with ice covering top and bottom. The shrimps were separated from the ice by fine-meshed nylon netting above and below to facilitate handling. The temperature in the cold storage room was approximately 5°C during the tests.

The other curing methods had in common that the shrimps were stored in a liquid (bulk curing). The ratio of shrimps to liquid was always 1:3. Table 2 shows the curing conditions for all tests.

Page 8 TABLE 2. Curing conditions for samples 1-15 in tests 1-7.

TEST No	SAMPLE No	CURING METHOD
1	1	Control: covered with ice in crate. Curing time: 12 hours.
	2	Bulk curing: Stored in fresh water with Brifisol 512* added. Curing time: 12 hours.
2	3	Control: covered with ice in crate. Curing time: 20 hours.
	4	Bulk curing: Stored in fresh water. Curing time: 20 hours.
3	5	Control: covered with ice in crate. Curing time: 20 hours.
	6	Bulk curing: Stored in sea (water) with 35 o/oo salinity. Curing time: 20 hours.

Continued

TEST No	SAMPLE No	CURING METHOD
4	7	Control: covered with ice in crate Curing time: 20 hours.
	8	Bulk curing: Stored in sea(water) with 35 o/oo salinity. Curing time: 20 hours.
5	9	Control: covered with ice in crate. Curing time: 20 hours.
	10	Bulk curing: Stored in blend of sea and fresh water (Ratio: 1:1). Salinity: 17.5 o/oo. Curing time: 20 hours.
6	11	Control: covered with ice in crate. Curing time: 20 hours.
	12	Bulk curing: Stored in sea (water) with 10 o/oo sea salt added. Total salinity: 45 o/oo. Curing time: 20 hours.
7	13	Control: covered with ice in crate. Curing time: 20 hours.
	14	Bulk curing 1: Stored in sea (water) with 27 o/oo salinity. Curing time: 20 hours.
	15	Bulk curing 2: Stored in fresh water with 35 o/oo sea salt added. Curing time: 20 hours.

* Brifisol 512 is a blend of tripolyphosphate, pyrophosphate and hexametaphosphate.

Salinity was measured with a Yellow Springs Instrument Co. salinometer Model 33.

The total weight after curing was recorded prior to weighing three parallel samples of three kg each for machine peeling. Based on the weight recorded before curing and the weight after curing, the change in weight during the curing process was calculated. The formula for weight change is:

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$$\text{Change in weight} = \frac{\text{weight after curing - weight before curing}}{\text{weight before curing}} \times 100\%$$

Draining time after curing and before weighing was 30 minutes. A Sauter EB 60 was used for weighing; it has a deviation of +/- 10 g up to 30 kg.

2.1.3 Measuring procedures and equipment used in machine peeling

The shrimps were machine-peeled on a Skrmetta peeling machine provided by Rya Fiskeindustri (Fish Processing) Ltd.

Feeding (into machine)

The shrimp specimens were fed directly onto one fifth of the width of

the cooking belt, using a feeding time of one minute per kg shrimps. This corresponds to a peeling capacity of 300 kg whole raw shrimps per hour.

Addition of water to the peeling plane

The quantities of water on the peeling plane were measured and kept constant during the peeling of shrimps using rotameters (water quantity meters) installed on the water supply hoses of the peeling plane. There are 10 supply hoses to the nozzles on the peeling machine: 7 on the upper peeling level and 3 on the lower peeling level. In addition the peeling machine is rinsed from below but that water quantity was not measured. On the upper peeling level the water quantities in tests 1-3 were maintained at 760, 200, 200, 0, 200, 0 and 200 litres per hour (listed from above and downward on the peeling level). Following test No 3 the coupling to the second uppermost nozzle broke down and the quantity of water at the third uppermost nozzle was subsequently increased to 400. On the lower peeling level the water quantity was 200, 0 and 200 litres/hour respectively in all tests.

Finger pressure

Strong finger pressure was applied in tests 4 and 7 while no finger pressure was used in the other tests.

Page 10 Collection of the product

The partially peeled shrimps were collected on a strainer immediately after the peeling machine. The specimens were then packaged in plastic bags and dispatched to FTFI for more detailed grading and weighing.

Measurement of peeling yield, degree of clean peeling and content of damaged material

The shrimps were sorted into the following groups:

A - Cleanly peeled whole shrimp muscle
B - Cleanly peeled bits of muscle
C - Shrimps with shell(adhering)
D - Loose shells

Shrimps with shells adhering (C) were then clean-peeled and graded into three groups:

E - Shells

F - Whole shrimp muscles

G - Bits of muscle

The individual fractions were then weighed and calculations were carried out.

$$\text{Peeling yield} = \frac{(A + B + F + G) \times 100\%}{(3 \text{ kg raw whole shrimps}) \times (1 - \text{weight change}/100)}$$

In order to obtain the effect of the curing methods on the peeling yield, an adjustment must be made taking into account the weight change during curing.

$$\text{Degree of clean peeling} = \frac{(A + B) \times 100\%}{A + B + C}$$

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In the first four tests a large portion of the shrimps was free of shells on the tail muscle with the head loosely adhering. If a cleaner had been used after the peeling machine the major portion of the heads would likely have been removed; the degree of clean peeling calculated according to above formula produced therefore an unrealistically low figure. In tests 5-7 the share of shrimps with shell-free muscles and with heads was therefore measured. Group C (shrimps with shells) was sorted into two portions: C1 - shrimps with heads and shell-free muscle and C2 -shrimps with shells on the tail, with or without head. The share of shrimps with head and shell-free muscle among all shrimps with shells is calculated as shown below:

$$\text{Share of shrimps with heads and shell-free muscles} = \frac{C1}{C1 + C2} \times 100\%$$

$$\text{Share of bits} = \frac{(B + G) \times 100\%}{A + B + F + G}$$

Bits are defined as shrimps or parts of shrimps which measure less than 15 mm.

2.1.4 Other analyses

Water content

The water content is measured in raw shrimp muscle after peeling and

drying of the specimens in an oven at 105° C (AOAC, 1980). Three parallel tests were carried out on each specimen. In tests 6 and 7 the water content was also measured before curing.

pH

10 grams of shrimp muscle with 10 ml 0.15 M KCl added were used for pH measurements; they were homogenized in an Ultra-Turrax homogenizer type TP 18/10. Subsequently pH was measured with a "Radiometer Copenhagen PH 61 Laboratory" pH-meter. In tests 6 and 7 pH was also measured before curing.

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Manual peeling

In tests 5-7 approximately 500 grams of shrimps were removed after curing and peeled manually. Prior to weighing the shrimps were drained for 15 minutes. The peeling yield was measured.

Cooking of peeled raw shrimps

In test 1 a cooking experiment was carried out with machine-peeled shrimps. 300 grams of shrimp muscle were weighed in and cooked in a vat with 3 litres of water containing 5% added salt. The shrimps were cooked for 20 seconds, 1 minute and two minutes. The shrimps were drained for 15 minutes before and after cooking, prior to weighing. The cooking loss was measured.

Deep-frying of peeled shrimps

In test 4 shrimps were deep-fried in oil after machine-peeling. They were dipped in batter before deep-frying. Both home-made batter (see recipe in enclosure 2) and batter for commercial use were evaluated. Weight change during deep-frying was measured by weighing the shrimps before and after frying for 30 seconds. Draining time was 15 minutes. The product quality was evaluated in simple visual examinations and in tasting tests.

Statistical analyses

With a view to investigating whether there were significant differences in peeling yield, degree of clean peeling, content of debris and water content between bulk curing and regular covering with ice in boxes, a "one way" analysis of variance was used. The calculations were carried out using the PC statistics program Statpro (ANON, 1985).

In test 7, where the shrimps were cured before peeling by three different methods, the analysis of variance will indicate only whether there is a

significant difference between the three groups and not whether there is a significant difference between any (particular) groups. To investigate this, Duncan's Multiple Range Test was used (MONTGOMERY, 1984).

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2.2 PEELING WITH A PEELING MACHINE EQUIPPED FOR PEELING RAW SHRIMPS

There is no peeling machine fully equipped for peeling raw shrimps in Norway. In the U.S.A. shrimps have been peeled in a raw condition for a number of years, and the manufacturing equipment has there been adapted to this method. With a view to becoming familiarized with the American method of peeling raw shrimps, the manufacturers of shrimp peeling machines, Skrmetta in New Orleans, were visited in August 1987. Skrmetta is also engaged in commercial peeling of shrimps.

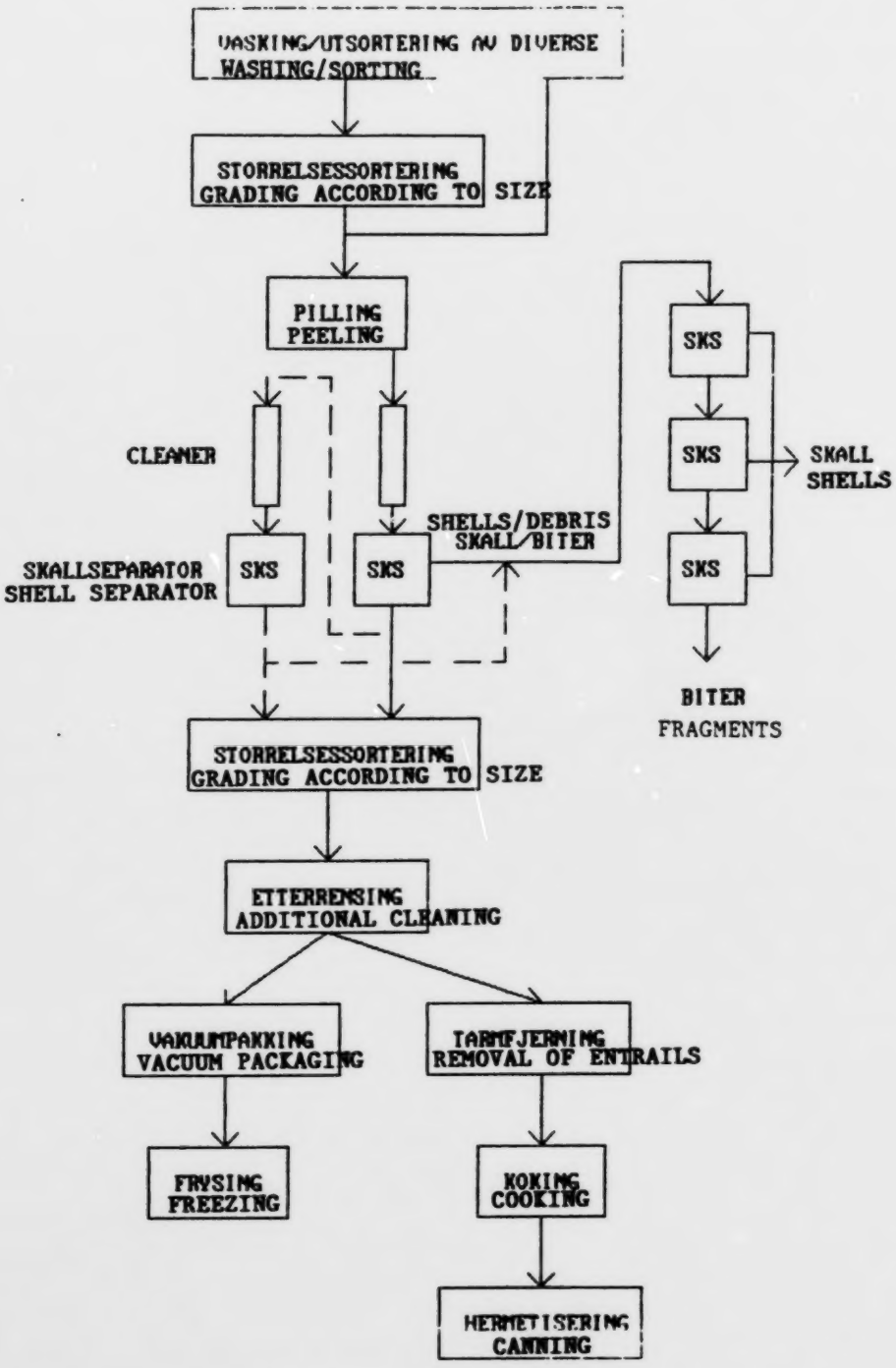
2.2.1 Description of an American shrimp plant

The plant has five peeling machines. They peel exclusively raw shrimps, mainly brown-grooved shrimp, Penaeus aztecus.They peeled (at time of visit?) only fresh shrimps which were received covered by ice in wooden crates. The manufacturing process in the plant is shown in figure 1.

The peeling machine itself is basically the same as is used in Norway. The steel rollers, which measured 9/16" (approximately 14.3 mm) are different in that they are sandblasted along their entire length whereas in Norway they are sandblasted only at the top. The bottom rollers in the lowest roller section were furthermore covered with rubber; in Norway the surface on these rollers is commonly smooth steel.

The cleaning process following the peeling machine is different from that used in Norway. Skrmetta had two sets of cleaners and shell separators (roller type) after each machine. It was possible to use one or two sets, depending on the degree of clean peeling. Shells and debris were passed through three shell separators in a separate operation and the debris were sold as a special product. The cleaners were rubber-covered internally.

Prior to packaging the shrimps were graded and additionally cleaned. The product was either canned or vacuum-packaged and frozen. Shrimps, which were canned, were passed through a machine which cut off the entrails.



FIGUR 1. Flytskjema over rekeproduksjonen i Skrmetta Machinery Corporation.

FIGURE 1 Flow diagram of shrimp manufacture at the Skrmetta Machinery Corp.

Page 15 2.2.2. Peeling tests

17 kg shrimps (Pandalus borealis , caught by the trawler "Heidi Vibeke" in the Barents Sea on 18 May 1987) were sent to the U.S.A. The shrimps were packaged in insulated Arena crates with dry ice. On arrival in New Orleans they were still frozen. The objective was to peel these shrimps with the equipment used by the Americans in industrial peeling of raw shrimps.

The shrimps were thawed in a container in water which was maintained at 24° C at the beginning of the thawing process. Following thawing the shrimps were covered with ice in a crate and stored in a cold storage room until the following day. As an initial test 1 kg of shrimps was peeled immediately after thawing. Prior to peeling the peeling rollers were scrubbed clean. During peeling much water was used on the rollers but no finger pressure was applied. The rate of dosage was approximately 300 kg/hour (one fifth of the peeling plane was used.).

The peeling yield was 41% and the shrimps were almost 100% clean peeled. There were no shrimps with heads (attached), which was the most serious problem in earlier tests carried out in Norway. A contributing reason why uncured shrimps were cleaned with almost 100% efficiency was the fact that the rollers were recently cleaned. In time fat from the shrimps will be deposited on the rollers and the friction will be reduced. Rollers, which were recently cleaned, will peel effectively to begin with because the fat has been washed off.

Four samples cured for 22 to 25 hours were peeled. Prior to peeling, brown shrimp was peeled for four hours in order to "run in" the rollers following cleaning. Two of the samples were removed after the peeling machine, one sample was removed after the cleaner, and one sample was also passed through the cleaner and shell separator. The shrimps were weighed before and after peeling following 30 minutes draining. The peeling yield was calculated according to the formula:

$$\text{Peeling yield} = \frac{\text{Clean peeled muscle}}{\text{Quantity fed}} \times 100\%$$

The degree of clean peeling was expressed as the number of shrimps with shells following peeling.

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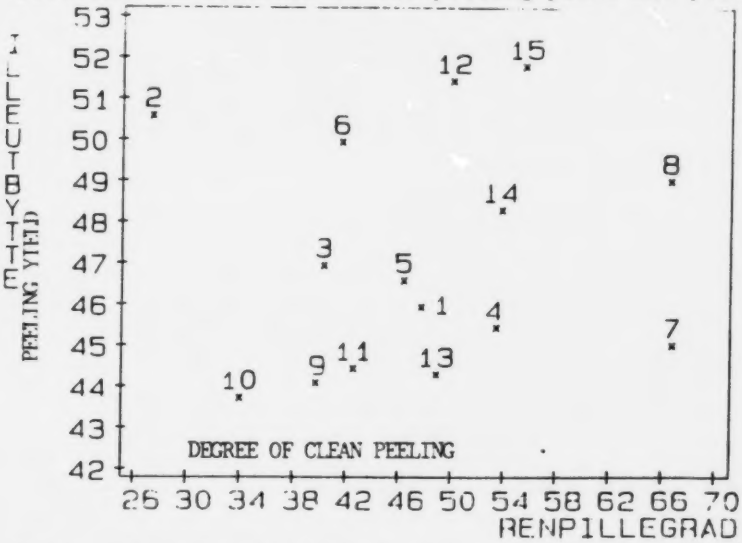
3. RESULTS AND DISCUSSION

3.1 PEELING WITH A PEELING MACHINE EQUIPPED FOR PEELING COOKED SHRIMPS

Peeling yield and degree of clean peeling

Results for machine peeling of raw shrimps are shown in enclosure 1. Figure 2 shows the relationship between peeling yield and degree of clean peeling. The peeling yield in the peeling of raw shrimps was generally very high and varied between 43.7 to 51.8%. The extraordinarily high peeling yield compared with the peeling yield for cooked shrimps is due partly to the fact that the cooking loss is eliminated and partly to the greater elasticity of the raw shrimp muscle and also to a mucous membrane which covers the surface and which acts as a lubricant. Raw shrimps are therefore more resistant to friction on the peeling plane and produce a higher peeling yield.



Test No	Treatment procedure
1	Covered with ice in crate for 12 hours
2	Treated with 2% Brifisol 512 for 12 hours
3	Covered with ice in crate for 20 hours
4	Fresh water for 20 hrs
5	Covered with ice in crate for 20 hours
6	Sea (water) [35 o/oo] for 20 hours

Figure 2. Peeling yield, degree of clean peeling and treatment for all samples.

Test No	Treatment procedure
7	Covered with ice in crate for 20 hours. Peeled with finger pressure.
8	Sea (water) [35 o/oo] for 20 hours. Peeled with finger pressure.
9	Covered with ice in crate for 20 hours.
10	Sea (water) + water [17.5 o/oo] for 20 hours.
11	Covered with ice in crate for 20 hours.
12	Sea (water) + salt [45 o/oo] for 20 hours.
13	Covered with ice in crate for 20 hours. Peeled with finger pressure.
14	Sea (water) [27 o/oo] for 20 hours. Peeled with finger pressure.
15	Water + salt [35 o/oo] for 20 hours. Peeled with finger pressure.

Page 17 The peeling yield for the shrimps, which were covered with ice in crates and otherwise treated equally, varied between 44.1% and 46.9%, i.e. by 2.8% (see enclosure 1). This difference in yield is due primarily to changes in the quantity of water on the peeling machine. The second nozzle from the top on the peeling machine was not functioning after the third test, and this has probably resulted in a lower peeling yield. The uppermost steel rollers on the peeling plane have a rougher surface than those further down on that plane, and the quantity of water on the top is therefore important to the peeling yield. Another possible explanation of this variation could be that the peeling machine was in a different condition in the various peeling tests. Tests 1-3 were carried out in June and tests 4-7 took place in July when the shrimp plant had a general employees' holiday. When a peeling machine is not used frequently, the rollers will dry up and perform differently. In tests 1-3 the peeling yield for shrimps covered with ice in a crate was higher than in the other tests while at the same time the degree of clean peeling was about the same. Peeling in tests 4-7 appeared to have inflicted more severe wear on the shrimp muscle by comparison with tests 1-3.

Figure 2 shows that all samples with more than 47% peeling yield were bulk-cured (samples 2, 6, 8, 12, 14 and 15), and enclosure 1 shows that all these samples had significantly higher peeling yields than specimens which were covered with ice in a crate. Only the bulk-cured samples 4 and 10 produced a poorer peeling yield than shrimps covered with ice in a crate. These samples had in common that the salt concentration in the curing water was low, i.e. 0 o/oo for sample 4 and 17.5 o/oo for sample 10. The peeling yield thus appears to depend on the salt concentration of the curing water. Sample 4 had a significantly higher degree of clean peeling than the control sample (1% level), which explains part of the difference in yield. The samples with the highest peeling yield, where the degree of clean peeling was likewise high, were Nos 8, 12 and 15, i.e. samples which were bulk-cured in 35 o/oo sea (water) with 10 o/oo sea salt added, and fresh water with 35 o/oo sea salt added.

Page 18 Sample 8 had a peeling yield of 49.0% and a degree of clean peeling of 66.5%. A large portion of the "shrimps with shells" consisted of shrimps with heads (adhering)(and)muscles free of shells. Following sample 8 the share of

shrimps with heads and with muscles free of shells within the group "shrimps with shells" was therefore measured. Most of the heads will separate from the muscle in the cleaner.

Sample 12 had a peeling yield of 51.4% and a degree of clean peeling of 50.0%. This degree of clean peeling was unrealistically low because the share of shrimps with heads and muscles free of shells was 33.6%.

Sample 15 had a peeling yield of 51.8% and a degree of clean peeling of 55.6%. Among the partially peeled shrimps there was a large share of shrimps with heads (attached) and muscles free of shells, i.e. 66.7%. Shrimps in sample 15 had a significantly higher peeling yield than those in sample 14 (5% level) which were peeled at the same time. Shrimps in samples 12 and 15 had a firm texture which made them well suited to withstand the friction applied by the rollers.

The degree of clean peeling following the peeling machine in industrial production of cooked shrimps varies commonly between 70 and 80%, measured by the method listed in section 2.1.6. The degree of clean peeling in samples 8, 12 and 15 would have been satisfactory in industrial production when it is considered that the samples were taken ahead of the cleaner. It was previously shown that the cleaner increases the degree of clean peeling with cooked shrimps by approximately 15% and air bubbles by approximately 3% but this may vary, depending on raw material and adjustment of the peeling machine (AANESEN et alia, 1987). There is reason to believe that the cleaner would have increased the degree of clean peeling still further with the raw shrimps because of the large share of shrimps with heads and with muscles free of shells.

It should be pointed out that the machine, which was used for the peeling of raw shrimps, was equipped with a rubber covering on the bottom rollers in the lowest roller section while these rollers have a smooth steel surface in many shrimp plants in Norway. The rubber covering produces extra firm peeling since this part of the peeling plane does not have small steel rollers (insert rollers).

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Shrimps treated with phosphate (sample No 2) had a high peeling yield (50.6%) but the degree of clean peeling was significantly lower than for the control sample (1% level). Treatment with phosphate makes the shrimp shell smoother, and the grip of the rollers of the peeling machine on the shell is therefore poorer.

In tests 4 and 7 strong finger pressure was used during peeling,and as a result some of the shrimps were a little squeezed.

Share of fragments

Enclosure 1 shows that the content of fragments was low for all samples by comparison with cooked peeled shrimps. This was presumably part of the reason for the high peeling yield. The content of fragments varied from 0.8% to 4.5% but there were no significant differences between the various curing methods.

Water content

The water content in all samples is listed in enclosure 1. Prior to curing it was measured only in tests 6 and 7 and was 80.0% and 79.9% respectively. The water content in shrimps following curing varied in all tests from 83.8% to 86.2%. This is very high by comparison with previous experience. In the shrimp muscle the water content increased by up to 6.3% during curing.

In test 1 the water content for phosphate-treated shrimps was significantly lower than for shrimps covered with ice in a crate (1% level). In tests 3 and 6 it was almost identical for both curing methods. In tests 2, 4, 5 and 7 the water content for bulk-cured shrimps was significantly higher than for those covered with ice in crates.

The water content in the tests was extraordinarily high (up to 86.2%) by
Page 20 comparison with earlier tests carried out at FTFI. MALNES et al. (1987) described tests with various treatments of the shrimp material where the water content after curing varied from 77.8% to 80.8%. Prior to curing the water content in the same tests varied from 77.1% to 78.5%. These shrimps were caught late in the fall. Shrimps are known to be a very variable raw material with large seasonal variations. The present raw material was caught in the spring and has basically a higher water content than that from previous tests. It absorbs furthermore considerably more water during curing.

The water pickup during curing is affected by many factors, among others curing conditions and the muscle's ability to attract water.Shrimps absorb water when myofibrils (flesh fibres which carry out the muscular work) increase their volume by lateral swelling. The factors, which affect the degree of swelling, are resistance in the myosin-actin bonds, Z and M lines, connective tissue and/or increase in electrostatic repulsion (OFFER, 1984). The high water content in the shrimps may consequently be due to low resistance to swelling and/or strong electrostatic repulsion.

Change in weight

The weight of whole shrimps covered with ice in crates was reduced by between 3.2% and 7.2% during the curing process (see enclosure 1). This weight reduction does not consist of water lost from the tail muscle, as is apparent in tests 6 and 7 where the water content in the muscle increased by 4.6% and 4.5% respectively. Bulk-cured shrimps, on the other hand, increased in weight during curing by 2.2% to 8.5%, apart from test 2 where shrimps stored in fresh water lost 1.8% of their weight.

The change in weight during the curing process appears to depend on the salt concentration in the curing water. Storage in fresh water (0 o/oo concentration) resulted in a weight loss of 1.8% during curing while a sea salt addition of 35 o/oo to fresh water resulted in a weight increase of 8.5%. Sea
Page 21 (water) and sea salt contain substances which affect the electrostatic repulsion in the muscle. In addition to common salt (NaCl) they contain among others magnesium chloride ($MgCl_2 . 6H_2O$), potassium chloride (KCl), sodium sulphate (Na_2SO_4) and calcium chloride ($CaCl_2.2H_2O$), (SIEBURTH & JENSEN, 1967).

Addition of phosphate to the curing water resulted in a weight increase of 4.7% after 12 hours curing.

pH

Enclosure 1 shows that there were no great differences in pH after curing. pH for bulk-cured shrimps was equal to or lower than for those covered with ice in crates, apart from the reading in test 1. In test 1 phosphate was added to the curing water for the bulk-cured shrimps, and it is therefore natural that the pH is higher for these. In tests 6 and 7 pH was also measured before curing, and it was found that it was higher in all tests during the curing process. This agrees with SOLBERG & NESBAKKEN (1981) who found that pH increased during ice storage of shrimps.

Manual peeling

The peeling yield for manual peeling was always higher for bulk-cured shrimps (see enclosure 1). Bulk-cured shrimps may have picked up more water and salts in the muscle than those covered with ice in crates. In manual peeling it was clearly easier to peel the bulk-cured shrimps; the shell was softer and was easier to remove from the muscle. The higher peeling yield for bulk-cured shrimps is probably a combination of these factors.

In tests 12-15 the peeling yield was lower in manual peeling than in machine-peeling. This relationship is normally reversed. During machine peeling the tail and neck protrusions were often adhering to the muscle while these were frequently pinched off in manual peeling, which may explain above results.

Page 22 Cooking of peeled shrimps

The cooking loss for shrimps cooked after peeling is shown in table 3. It was found that the loss increased with increasing cooking time .

TABLE 3. Cooking loss with various cooking times for peeled shrimps cooked in salt water.

COOKING TIME	20 seconds	1 minute	2 minutes
COOKING LOSS	12.5%	23.0%	25.1%

The shrimps curled up during cooking like they curl up when cooked in the shell but the surface appeared frayed and not very attractive. The taste was poor and so was the texture. Because of the poor product properties and the large cooking loss an industrial cooking of shrimps after peeling will be of no interest.

Deep-frying of peeled shrimps

Following application of batter and subsequent deep-frying the product weight increased in all instances. After application of commercial batter the weight of the shrimps increased on the average by 33.1% (standard deviation 2.6). Following application of homemade batter (see recipe in enclosure 2) the weight increased by 36.4%. Shrimps with homemade batter and rolled in bread crumps prior to deep-frying increased in weight by 118.2% but this product is of little interest since the crumps make up an excessive share of its weight. In the U.S. a limit of 35% has been laid down for the content by weight of

batter in the product (SUDERMAN, 1983). Shrimps with commercial or homemade batter are a superb product with an attractive appearance and good taste and textural properties. Fried shrimps with batter are a product which is already available on the market. Examples of commercial products, which resemble fried deepwater shrimp in size and appearance, are shown in enclosure 3.

Page 23 3.2 PEELING WITH A PEELING MACHINE EQUIPPED TO PEEL RAW SHRIMPS

Table 4 shows results obtained in peeling cured shrimps including initial peeling of not cured shrimps.

TABLE 4. Results obtained in the peeling tests. The table shows where the shrimps were sampled, the dosage in kg/hour, the weight of the sample in kg, the peeling yield (PU) and the degree of clean peeling (RPG).

TEST	SAMPLED FOLLOWING	DOSAGE	QUANTITY	PU	RPG
INITIAL	peeling machine	300	1.00	41.0%	3 with shell
1	peeling machine	380	2.27	44.0%	34 w/shell
2	peeling machine	380	2.27	43.1%	25 w/shell
3	cleaner	370	2.27	41.2%	1 w/shell
4	shell separator	245	7.26	41.4%	0 w/shell

The peeling yield with cured shrimps was 2-3% higher than with non-cured shrimps but the degree of clean peeling was poorer (tests 1-2 compared with the initial test). The reason for the poorer degree of clean peeling when peeling cured shrimps was presumably the recent washing of the rollers when the noncured shrimps were peeled.

The degree of clean peeling was considerably higher when the shrimps were passed through the cleaner but the peeling yield dropped (see test 3). In test 4 the shrimps were passed through one cleaner and one shell separator. The shrimps were completely peeled and in spite of all a peeling yield of 41.4% was achieved. The shell separator does thus not appear to reduce the peeling yield.

Page 24 3.3 CONCLUSION

The tests showed that the deepwater shrimp can be readily peeled in a raw condition. An acceptable degree of clean peeling was achieved with the same equipment which is used to peel cooked shrimps, and the peeling yield was very high. It should be noted that the peeling yield in this report includes only losses in the peeling process (in some tests also in the cleaner and shell separator) but not before and following these links in the processing. In industrial production the peeling yield will also include thawing losses, losses incurred in transportation from the peeling machines, losses in secondary peeling, in the freezer etc. In industrial processing the peeling yield will probably be between 40 and 45%, including glazing.

With a view to further increasing the degree of clean peeling, the peeling machine can be equipped with steel rollers (insert rollers) which have a rough surface along their entire length, the lowest rollers in the bottom roller section can be covered with rubber and installation of shell separators of the roller type can be considered. With such equipment a degree of clean peeling of 100% and a peeling yield of 41.4% (excluding glazing) was achieved. Such a high degree of clean peeling would not be realistic in practice since it would affect the peeling yield excessively but it shows that raw shrimps can be peeled intensively while at the same time a high peeling yield can be obtained.

A large portion of the shrimps, which were partially peeled in the peeling machine, had the heads adhering while the muscle was free of shells. By using "insert rollers", which were rough along their entire length and with an internally rubber-covered cleaner this problem was solved. These modifications will also reduce the use of finger pressure which results in squeezed shrimps.

By curing the shrimps in sea water or fresh water, to which sea salt is added, (with a salt concentration of 35-45 o/oo) the peeling yield can be increased by up to 7.5% (sample 15 by comparison with sample 13). Shrimps, which are cured in this way, increase in weight by up to 8.5% during curing.

Page 25 Raw peeled shrimps can be sold frozen singly and glazed to e.g. restaurants. Restaurants have experienced problems when trying to obtain raw peeled shrimps (Harald Brox, personal communication); among others these are used in flambé

dishes.

Cooking of shrimps after peeling is of no interest because it results in excessive cooking loss and poor product properties.

There is, however, merit in an application of spiced batter before single freezing at the shrimp plants and in packaging in consumer packages (batter content approximately 30%). The consumers will then fry the shrimps in a frozen condition (see enclosure 3). Shrimps prepared in this fashion are a very attractive product which are well suited to establish themselves on the market.

In England some importers of cooked peeled shrimps have started to sort out fragments and small shrimps and to reshape these into larger shrimps. The reshaped shrimps are then treated with batter and fried. Reshaping of fragments and small shrimps, which were peeled in a raw condition, will likely produce a more succulent product of better quality.

The market for raw peeled deepwater shrimps has been little investigated but the market is clearly interested. Representatives of the U.K. company Marks and Spencer, who were visiting FTFI, expressed interest in a trial order of raw peeled shrimps.

The price of raw peeled shrimps is difficult to predict but figure 3 shows how the total revenue is affected by varying product prices and peeling yield.

The figure indicates that the total revenue will increase drastically if the same price per kg can be obtained for raw peeled shrimps as for cooked peeled shrimps. Glazed raw shrimps will increase the total income by 33-50% when the peeling yield is between 40 and 45% which should be achieved in bulk-curing. Application of batter before freezing should produce a peeling yield of up to 55%, which represents an increase in total revenue of 83% at an unchanged price per kg.

Page 27 A reduction in the price of the finished product by 25% will result in an unchanged total income when the peeling yield is 40%. A peeling yield of 45% will produce an increase in total revenue of approximately 12%. Application of batter will increase total income by approximately 37% with this

finished product price.

Page 26

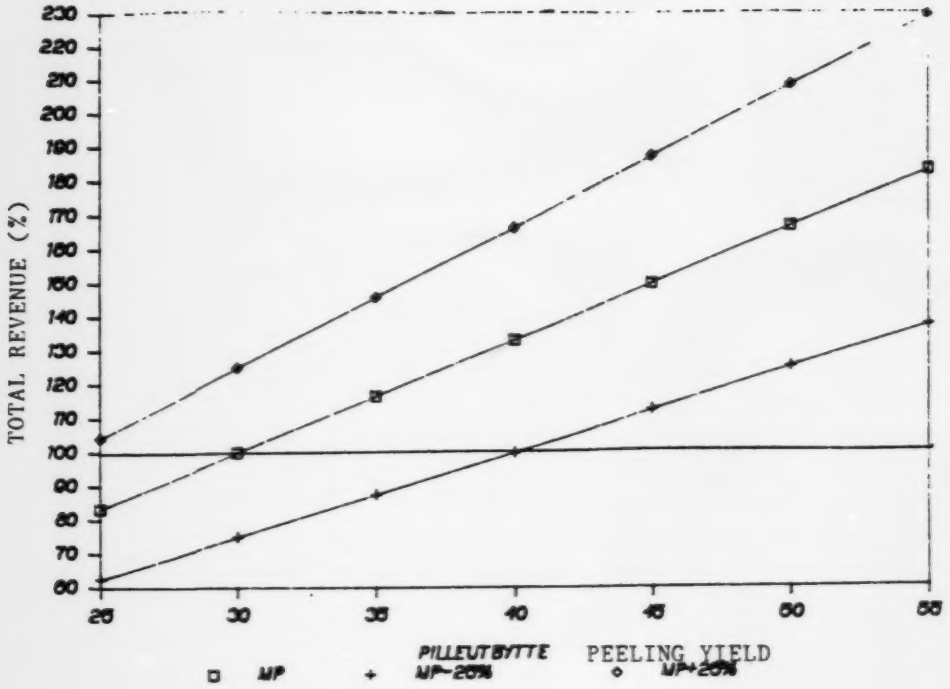

FIGURE 3. Percentage change in total income as a function of product price and peeling yield. The peeling yield includes glazing or batter application. The line in the centre shows the relationship at the normal market price for cooked peeled shrimps, the top line shows conditions for a 25% increase in the market price and the bottom line indicates the situation for a 25% reduction in the market price. A peeling yield of 30% (including glazing) at a normal market price for cooked shrimps produces an unchanged total income (100%). MP = market price of cooked peeled shrimps.

An increase of 25% in the price of the finished product will produce an increase in total income even with a peeling yield as low as 25%. An increase in peeling yield to 55% will result in a dramatic increase of approximately 130% in total revenue.

Figure 3 shows only changes in total income. It is obvious that the production of raw shrimps will entail increased costs, particularly if they are sold after application of batter. Increased costs when starting production of raw peeled shrimps consist of purchase of additional equipment and its installation, as well as increased sales expenses. The modifications of peeling

machines and cleaners as mentioned above can be rapidly implemented in that the conversion of the plant (exchanging insert rollers etc.) will take no more than 1-2 days. For the application of batter it will be necessary to invest in machinery which will likewise result in higher variable costs (maintenance, power, batter etc.).

A general estimate of profitability at the start-up of peeling of raw shrimps will be difficult since there are many uncertainty factors which are involved. Each individual peeling plant must assess profitability based on its own situation. The greatest uncertainty factor is nevertheless common for all operations, and that is the price which the market is willing to pay for the product. The available quantity of raw material, the freedom of action economically, the manufacturing premises etc. will, however, vary from plant to plant, and this will affect the calculation of profitability.

In the starting-up phase it must also be expected that some time and funds are needed to achieve the desired flow of production. Product development is a costly process but it is essential if a satisfactory result is to be obtained. Another factor, which may increase the costs,are increased
Page 28 hygienic requirements. If a product is manufactured for consumption without previous cooking or some other sterilizing process, then the hygienic conditions in the shrimp plant must be very good.

It would, however, appear that there is such a great potential in an increase of total income, due to the high peeling yield, that peeling of raw shrimps has excellent prospects of being profitable.

Page 29 ## 4. THE KRONBORG SHRIMP PEELING MACHINE

4.1. The mode of operation of the peeling machine

The Kronborg shrimp peeling machine, which was used in the tests, consists of feeding vat, cooking vat, cooling vat, temperating vat and vacuum chamber (see figure 4), and the shrimps are passed through the machine in this sequence. From the vacuum chamber they are pumped by a hose (peristaltic?) pump to the shell separating equipment; from there the shrimps move to regular aftercleaning. The peeling machine was originally designed for installation on board a vessel, and it is therefore extending upward to save space .

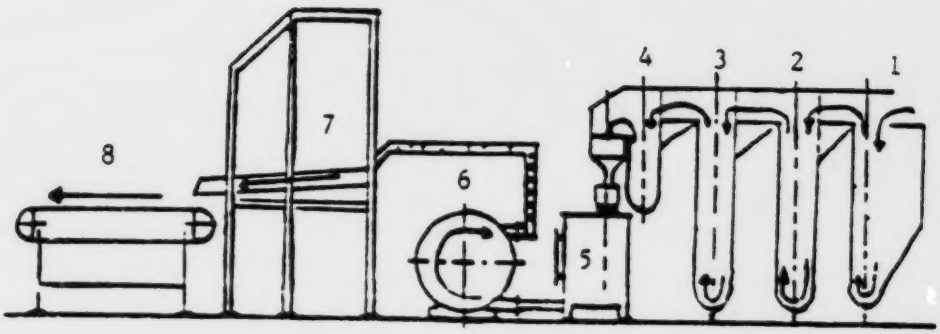

FIGURE 4. Flow diagram of the Kronborg peeling machine.

Legend: 1 = feeding vat 2 = cooking vat 3 = cooling vat
4 = "temperating" vat 5 = vacuum chamber 6 = hose (peristaltic?)
7 = shell sep. equipm. 8 = aftercleaning /-pump

The mode of operation of the machine is based on an entirely different principle than the conventional roller peeling machines. In the Kronborg machine the shrimps are peeled by a combination of explosion, collision and friction. In the process the shrimp muscle shrinks away from the shell during cooking, and water pockets develop between muscle and shell. Small air bubbles are formed when the water in these pockets is heated, and when these are exposed to a vacuum they will expand and separate the shell from the muscle. In
Page 30 order to avoid formation of air bubbles in the muscle the shrimps are cooled down after cooking. Formation of air bubbles in the muscles will result in torn muscles. Heating after cooling ("temperating") is of such a short duration that only the shell and the liquid between muscle and shell are heated up.

In the vacuum chamber the vacuum pump produces an adjustable reduced pressure. Feeding to the vacuum chamber takes place via three sluice valves which are closed and opened by air pressure. The peeling takes place in cycles

which are controlled by the opening and closing times of the sluice valves. The cycling time is adjustable; it is normally around one half second. When the sluice valve is closed, the vacuum pump will remove air and the pressure will decrease. When the sluice valve is opened, the blend of shrimps and air will be sucked in at a high velocity.

In the vacuum chamber two obliquely mounted plates are installed; their inclination is adjustable (see figure 5). These plates are continuously rinsed with water so that there is constantly a water film on their surfaces. The shrimps will collide with the uppermost inclined plate and slide down on it. They will then collide with the bottom plate and slide down to the bottom. The intensity of the collision and friction is adjusted by the inclination of the plates and the vacuum.

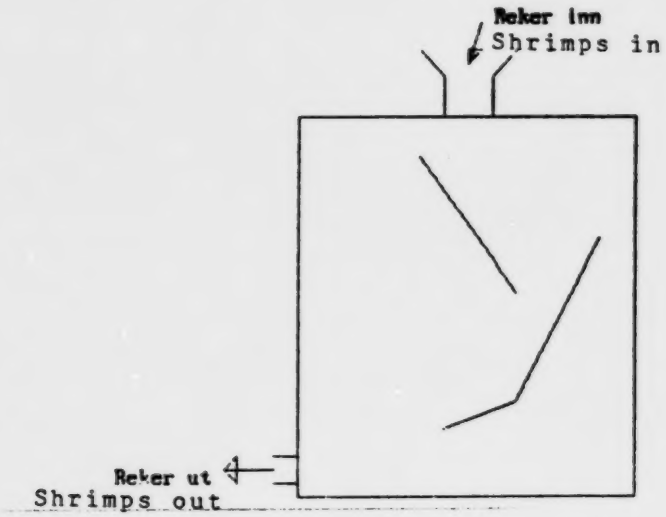

FIGURE 5 The vacuum chamber viewed from the side.

Page 31 A blend of muscle, shells and water is pumped out of the vacuum chamber to the shell separating equipment.

There are many adjustments/conditions on the shrimp peeling machine which can be varied; most of the options are listed below:

- Cooking time
- Cooking temperature
- "Temperating" time
- "Temperating" temperature

- "Temperating" medium (fresh water or sea water)
- Vacuum pressure
- Plate inclinations
- Feeding velocity
- Feeding frequency in vacuum chamber
- Closing pressure at sluice valve
- Lining on plates in vacuum chamber
- Water addition in vacuum chamber
- Opening on the cone (rubber linings on the top of the sluice valves)

4.2 Results obtained in peeling tests

FTFI has evaluated the Kronborg shrimp peeling machine with three types of raw material: shrimps cooked at sea, fresh shrimps (landed raw) and thawed shrimps frozen at sea. The evaluation was carried out as an assignment for Kronborg, and a detailed description of the tests is given in VIGGOSSON & MALNES (1987a and 1987b). A summary of the most important results is given below.

4.2.1 Shrimps cooked at sea

An evaluation of shrimps cooked at sea was carried out at the manual peeling plant John Johnsen in Aamøyhamn. The shrimps were caught by local shrimp trawlers and cooked immediately after catching. The age of the raw material before peeling varied from the day's catch to three days old shrimp catches stored in ice. Attempts were also made to peel frozen shrimps cooked at sea in a frozen and thawed condition.

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Since this type of machine is quite new, it was necessary to experiment with the adjustments in the beginning. The machine conditions were varied systematically and the results obtained determined further adjustments. In this way an understanding was arrived at how the various adjustments on the equipment will affect peeling results so that the plant can be operated consistently with optimum performance.

The various adjustments had varying effects on peeling results, and attempts were made to establish which of these were of the greatest importance. It was found that peeling results were strongly dependent on the raw material. Differ-

ent types of raw material will require different adjustments to achieve satisfactory results.

The shrimp material may vary greatly in shell hardness and muscle texture which are important factors in the Kronborg shrimp peeling plant. With some types of raw material very positive results were obtained where the machine-peeled shrimps were of almost the same high quality as manually peeled ones and could be sold as "bucket" (?) shrimps (Torbjørn Johnsen, personal communication). The average peeling yield in 24 yield measurements was 32.5% (standard deviation 3.2).

The Kronborg peeling machine has both advantages and drawbacks by comparison with the operation of conventional roller peeling machines. The shrimps may exhibit an appearance which may vary from manual peeling quality to a spoilt product. Among advantages it may be mentioned that the neck and tail points often adhere to the shrimps as opposed to conventional peeling where these are usually swallowed up by the peeling machine. The taste of the shrimps is better preserved for several reasons. The shrimps are peeled perfectly fresh,
Page 33 the cooking takes place in sea water, and the water consumption is lower on the Kronborg peeling machine which results in less leaching out of taste-producing substances. The texture of shrimps peeled on the Kronborg peeling machine resembles that of cooked shell shrimps and is therefore different from that of shrimps peeled with a conventional peeling machine.

Drawbacks associated with the Kronborg peeling machine may result in a frayed appearance of the shrimp muscle. The shrimp has a long and thin muscle which extends over the gut along the back of the tail muscle. The front part of this muscle often separates during peeling and remains adhering loosely. The muscle bundles on the side of the front half of the shrimp muscle may often separate from each other and give the shrimp a frayed appearance. The machine had furthermore a design which made cleaning difficult.

Among all possible machine adjustments it appears that the plate adjustments have the greatest effect on product quality but the vacuum pressure is also important.

"Temperating"temperature and time affect clean peeling of the shrimps. At

a low temperature the degree of clean peeling is low but it increases with rising temperature up to 94°C. The degree of clean peeling decreases when the "temperating"time is reduced from 25 to 6 seconds but the quality of the shrimps improves, i.e. they are less frayed.

Frozen shrimps cooked at sea produced poorer results than fresh shrimps cooked at sea. The peeling yield was lower, the degree of clean peeling was poorer and almost one third of the shrimps were frayed.

4.2.2. Fresh and thawed shrimps

The Kronborg peeling machine with drying conveyor, shell separator and required ancillary equipment were installed in the pilot plant at FTFI. The shrimp peeling plant was test-operated with shrimps cooked at sea, and the machine adjustments, which gave the best results at Aamøyhamn, were used.
Page 34 The peeling results were good, the shrimps were satisfactorily clean peeled, there was little fraying and most were undamaged and in good condition. In the tests with fresh and thawed shrimps the greatest emphasis was given to affecting the quality of the shrimps before they were passed to the vacuum chamber. The parameters, which were varied in the tests, are shown below.

* Curing conditions
  - Normal ice covering/bulk curing
  - Additives during bulk curing (CO_2, sodium bicarbonate, polyphosphate and salt)
  - Storage time

* Cooking
  - Cooking medium - sea water/fresh water
  - Addition of salt to cooking water
  - Cooking time

* Cooling
  - Cooling medium - sea water/fresh water
  - Cooling time

* "Temperating"
  - "Temperating"medium - sea water/fresh water
  - "Temperating"time

* Vacuum chamber
  - Vacuum pressure
  - Plate adjustment and lining
  - Addition of water in the vacuum chamber

The tests showed that fresh and thawed shrimps are not suitable for peeling on the Kronborg peeling machine. Fresh ice-covered shrimps and thawed shrimps do not have the same firm consistency as shrimps cooked at sea, and it appears that they can therefore not tolerate the type of strain to which they are exposed on the Kronborg peeling machine. They were peeled poorly; there were
Page 35 too many fragments, and the shrimps were frayed.

Shrimps cooked at sea have considerably harder shells than fresh and thawed ones. The shells become softer in storage, and this is probably a drawback when peeling takes place on the Kronborg peeling machine. The conventional roller peeling machines show, on the other hand, that the best results are obtained when the shells are soft.

Fresh shrimps produced better results than thawed ones. They were not as much crushed but their quality was by no means satisfactory.

The curing method, which produced the best results, was curing in fresh water, to which 50 o/oo sea salt were added. The improvement was, however, not sufficient to deliver an acceptable product.

A long cooking time (5 minutes) produced some improvement in peeling. The appearance of the shrimps was, however, not good enough. Such a long cooking time results furthermore in a large cooking loss.

Attempts were made to peel raw shrimps but this resulted clearly in poorer results than with cooked shrimps.

Improved peeling results were achieved in the tests when the shrimps were peeled without "temperating". The purpose of "temperating" is to form air bubbles in the liquid between muscle and shell prior to feeding into the vacuum chamber. The air bubbles expand in the vacuum chamber and burst loose the shell. If the shell is soft and yields when the air bubbles expand, the reason for warming up disappears. In such instances the function of the vacuum chamber will be solely

to speed up the shrimps before they land on the plates.

Varying conditions in the vacuum chamber failed likewise to produce a satisfactory product quality. It is concluded that fresh and thawed shrimps are not suitable for peeling on the machine.

Page 36 4.3. New design of the machine

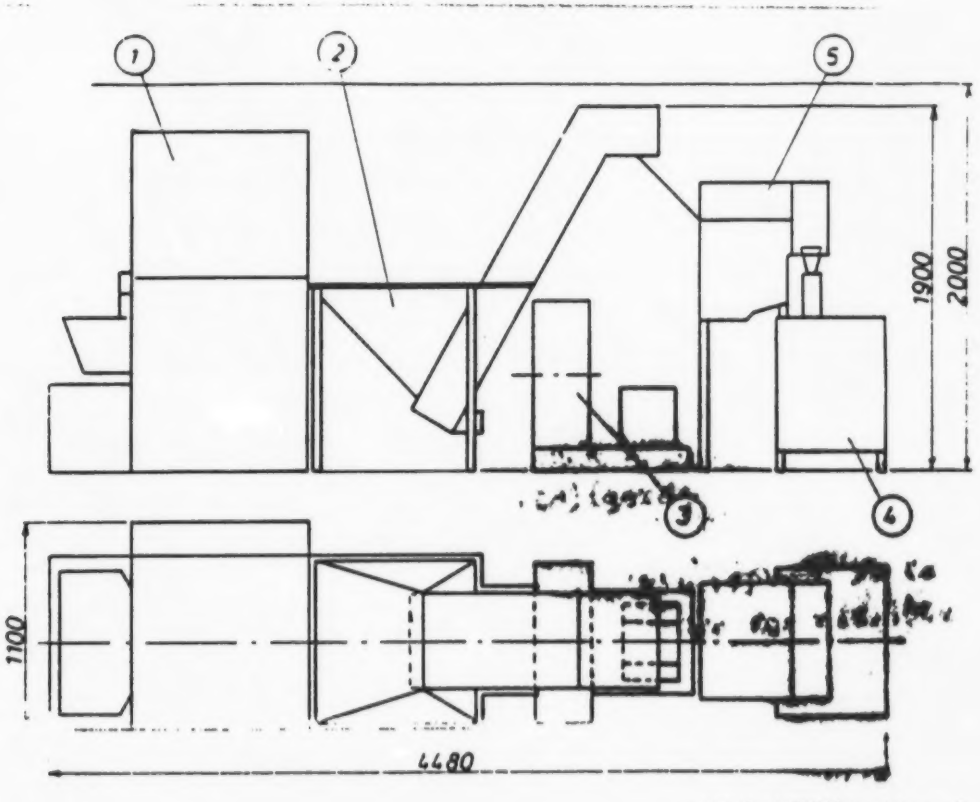

Figure 6. Diagram of the Kronborg peeling machine, latest model.
Legend: 1 = cooker (Kronborg 320), 2 = buffer storage, 3 = hose (peristaltic ?) pump, 4 = vacuum chamber, 5 = heater for warming up. ("temperating")

Based on the test results and evaluation at the Kronborg Machine Factory Ltd. a new design of the peeling machine was manufactured. The equipment, which is located before the vacuum chamber,was completely changed, and a new plate design inside the vacuum chamber was introduced. Figure 6 shows

a diagram of the new design of the Kronborg peeling machine.

Page 37 The shrimps are fed into the basket on the Kronborg 320 cooker, which is a batch cooker. They are cooked in batches of 30 kg, and after cooling they are dumped into the buffer storage. From there a conveyor leads to the "temperating"heater. Carriers on the conveyor feed a constant volume of shrimps to the "temperating" unit each time. The latter is a container with sea water maintained at a minimum temperature of 95°C. Special carriers move the shrimps through the sea water. From the "temperating" unit they pass to the vacuum chamber via the sluice valves.

The two inclined plates in the vacuum chamber are here removed, and a new arrangement was introduced. Persons interested in a more detailed description should apply directly to the Kronborg Machine Factory Ltd.

The shell separating equipment was also changed by comparison with the machinery used in the tests. In place of the dryer conveyor a wet drum (see enclosure 4) was installed. It consists of quadrangular steel pipes which are mounted on a circular frame at a distance of 2.5 mm between steel pipes. A blend of shrimp muscles and shells is pumped from the vacuum chamber to one end of the wet drum. The latter rotates and is rinsed internally so that shells and bristle are rinsed down between the steel pipes while the shrimp muscles are delivered at the other end. The remainder of loose shells and bristle are blown away with an air blower as before.

The new design of the shrimp peeling equipment has not yet been evaluated on board a vessel but it will likely have the following advantages by comparison with the previous construction.

1. It is easier to clean.
2. The cooker can also be used to cook shell shrimps.
3. The "temperating" time can be reduced to 3 seconds (in the previous warming up equipment the minimum dwell time was 6 seconds).
4. It is more consumer-friendly because of the new arrangement in the vacuum chamber.

Page 38 There is some uncertainty associated with the market for shrimps peeled

with the Kronborg peeling machine. "Kronborg shrimps" retain more tail and neck points but they may appear more frayed than those peeled with a conventional peeling machine. "Kronborg shrimps" retain the shrimp taste better because they are peeled completely fresh and with lower water consumption. The texture of "Kronborg shrimps" resembles more that of cooked shell shrimps than the texture of shrimps peeled with a conventional peeling machine. Shrimps peeled with a Kronborg peeling machine must therefore be characterized as a different product than those peeled with a conventional peeling machine. It is not known how the market will react, and many questions are associated with the introduction of the new product. Will it be accepted and by which markets?- Which price will be paid for the product?- The Kronborg shrimp peeling equipment is being installed on several vessels, and it will therefore not take too long until replies are obtained to these questions.

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ENCLOSURE 1 Test results obtained when peeling raw shrimps. The following properties are listed for all samples: Peeling yield, degree of clean peeling and share of fragments in machine peeling; water content in shrimp muscle before and after curing; pH in shrimp muscle before and after curing; weight change during curing process; peeling yield in manual peeling and share of shrimps with shell-free tails and with heads (adhering) following machine peeling. Results obtained in analysis of variance are shown with asterisks (* = significant difference at 1% level, ** = ... at 2.5% level and *** = ... at 5% level). Results obtained in Duncan's multiple range test for experiment 7 are listed with small letters (a is significantly different from b and c at the 1% level, b differs significantly from c at the 5% level).

TEST NO	SAMPLE NO	CURING METHOD	FINGER PRESS.	PEELG. YIELD	DEGREE OF CLEAN PEELG.	SHARE OF FRAGM.	WATER CONTENT BEFORE CURING	WATER CONTENT AFTER CURING	pH BEFORE CURING	pH AFTER CURING	WEIGHT CHANGE	MANUAL PEELG. YIELD	SHELL-FREE MUSCLE WITH HEAD
1	1	Covered w. ice in crate for 12 hrs	no	45.9(0.3)	47.7(1.9)	3.0(0.6)	-	85.9(0.4)	-	7.5	-3.2	-	-
	2	2% Brifisol 512	no	50.6(0.6)*	27.4(1.0)*	2.1(0.4)	-	83.8(0.1)*	-	7.6	+4.7	-	-
2	3	Covered w. ice in crate for 20 hrs	no	46.9(0.3)	40.2(1.7)	1.2(0.3)	-	84.4(0.2)	-	7.5	-5.2	-	-
	4	Fresh water	no	45.4(2.7)	53.5(1.3)*	0.8(0.6)	-	85.6(0.1)*	-	7.5	-1.8	-	-
3	5	Covered w. ice in crate for 20 hrs	no	46.6(0.3)	46.4(0.5)	0.8(0.3)	-	84.2(0.3)	-	7.6	-7.2	-	-
	6	Sea (water) 35 o/oo	no	49.9(0.5)**	41.6(4.1)	1.9(2.3)	-	84.1(0.2)	-	7.2	+5.4	-	-
4	7	Covered w. ice in crate for 20 hrs	yes	45.0(1.3)	66.8(2.5)	2.0(2.3)	-	84.5(0.2)	-	7.7	-4.6	-	-
	8	Sea (water) 35 o/oo	yes	49.0(1.0)***	66.5(3.1)	1.3(0.7)	-	85.4(0.1)*	-	7.4	+6.5	-	-
5	9	Covered w. ice in crate for 20 hrs	no	44.1(0.4)	39.8(3.1)	4.5(1.4)	-	84.3(0.3)	-	7.6	-4.0	45.8	31.4(1.7)
	10	Sea + water 17.5 o/oo	no	43.7(1.2)	34.0(4.4)	4.3(2.3)	-	85.2(0.1)**	-	7.6	+2.2	46.2	32.3(3.6)
6	11	Covered w. ice in crate for 20 hrs	no	44.4(1.0)	42.5(4.5)	2.4(0.7)	80.0(0.3)	84.6(0.1)	7.2	7.8	-5.4	44.7	44.5(0.8)
	12	Sea + salt, 45 o/oo	no	51.4(0.3)*	50.0(1.0)***	2.2(0.2)	80.0(0.3)	84.7(0.2)	7.2	7.4	+7.4	50.9	33.6(6.4)
7	13	Covered w. ice in crate for 20 hrs	yes	44.3(0.4)a	48.8(6.1)	1.4(0.8)	79.9(0.6)	84.4(0.2)a	7.1	7.6	-3.9	42.6	63.4(2.6)
	14	Sea, 27 o/oo	yes	48.3(0.2)b	53.8(1.2)	2.1(0.6)	79.9(0.6)	86.0(0.3)b	7.1	7.5	+7.9	44.1	67.4(6.1)
	15	Water + salt, 35 o/oo	yes	51.8(1.3)c	55.6(1.8)	2.6(0.4)	79.9(0.6)	86.2(0.1)b	7.1	7.6	+8.5	45.3	66.7(3.2)

Page 42 ENCLOSURE 2. Recipe for deepfrying batter used in the tests.

BATTER FOR DEEPFRYING

250 g wheat flour
1.5 decilitres beer (Brigg) [very light beer]
1.5 decilitres lukewarm water
1.5 tablespoons of oil
½ tablespoon of sugar
1 egg
5 g salt

Everything is stirred together but must not be worked hard. The batter is rested for two hours at room temperature. It is lightly stirred before use.

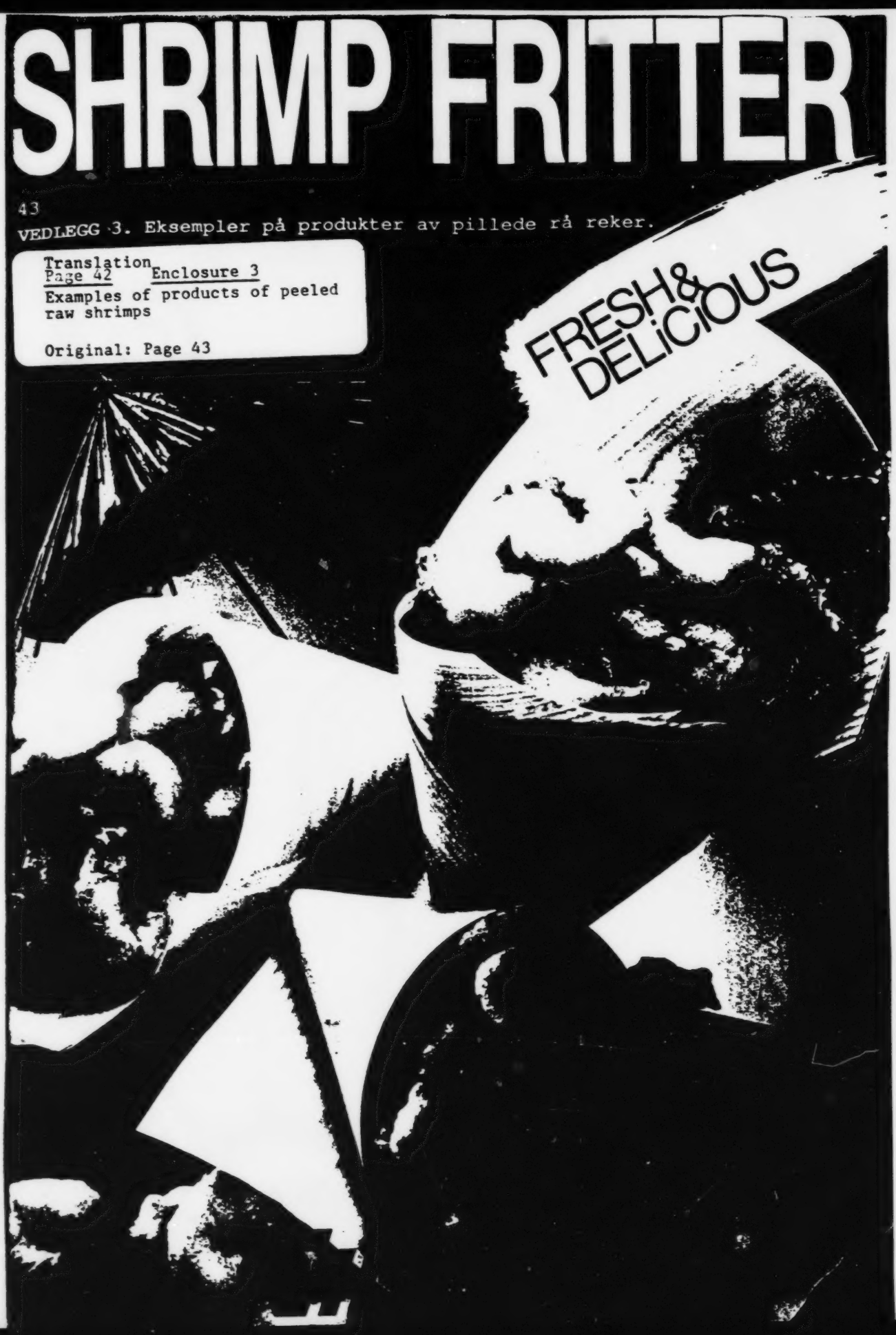
The recipe was obtained from Harald Brox, Head Chef at SAS Hotel in Tromsø.

VEDLEGG 3. Eksempler på produkter av pillede rå reker.

Translation
Page 42 Enclosure 3

Examples of products of peeled raw shrimps

Original: Page 43



VEDLEGG 3.
ENCLOSURE 3

SHRIMP FRITTER

Fresh shrimps, which have just been caught in Thailand, a land of shrimp growing, have been processed into "One-bite Shrimp Fritter."
Enjoy the crispy feeling to the palate of Shrimp Fritter as a snack or as garnishing of the main dish.

● Packing Style (Changeable according to your instructions) 1 kg × 10 bags/master carton	**● Ingredients** Shrimp Flour Rice powder Starch Egg powder Salt M.S.G. Baking powder Water
● Cooking Instructions (1) Place as-frozen shrimp fritters into an ample quantity of oil which has been heated to 170 - 180°C beforehand. (2) While stirring them from time to time, fry them for 1.5 to 2 minutes. (3) Garnish the shrimp fritters with your favorite vegetables and sause and eat.	**● Nutritious Information** Energy ..... 210 Kcal Protein Animal ..... 7.8 g Vegetable ..... 1.6 g Lipid ..... 12.5 g Carbohydrates Sugar ..... 13.1 g Fiber ..... 0.1 g Ash ..... 1.1 g Potassium ..... 168 mg Calcium ..... 72 mg Sodium ..... 151 mg Phosphorous . 102 mg Vitamin A ..... 10 IU Vitamin B_1 .... 0.05 mg Vitamin B_2 .... 0.08 mg Vitamin C ..... 1 mg Salt ..... 0.4 g
● Please Contact	**NICHIREI CORPORATION** 3-23, Misaki-cho, 3-chome, Chiyoda-ku, Tokyo 101, Japan

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ENCLOSURE 3

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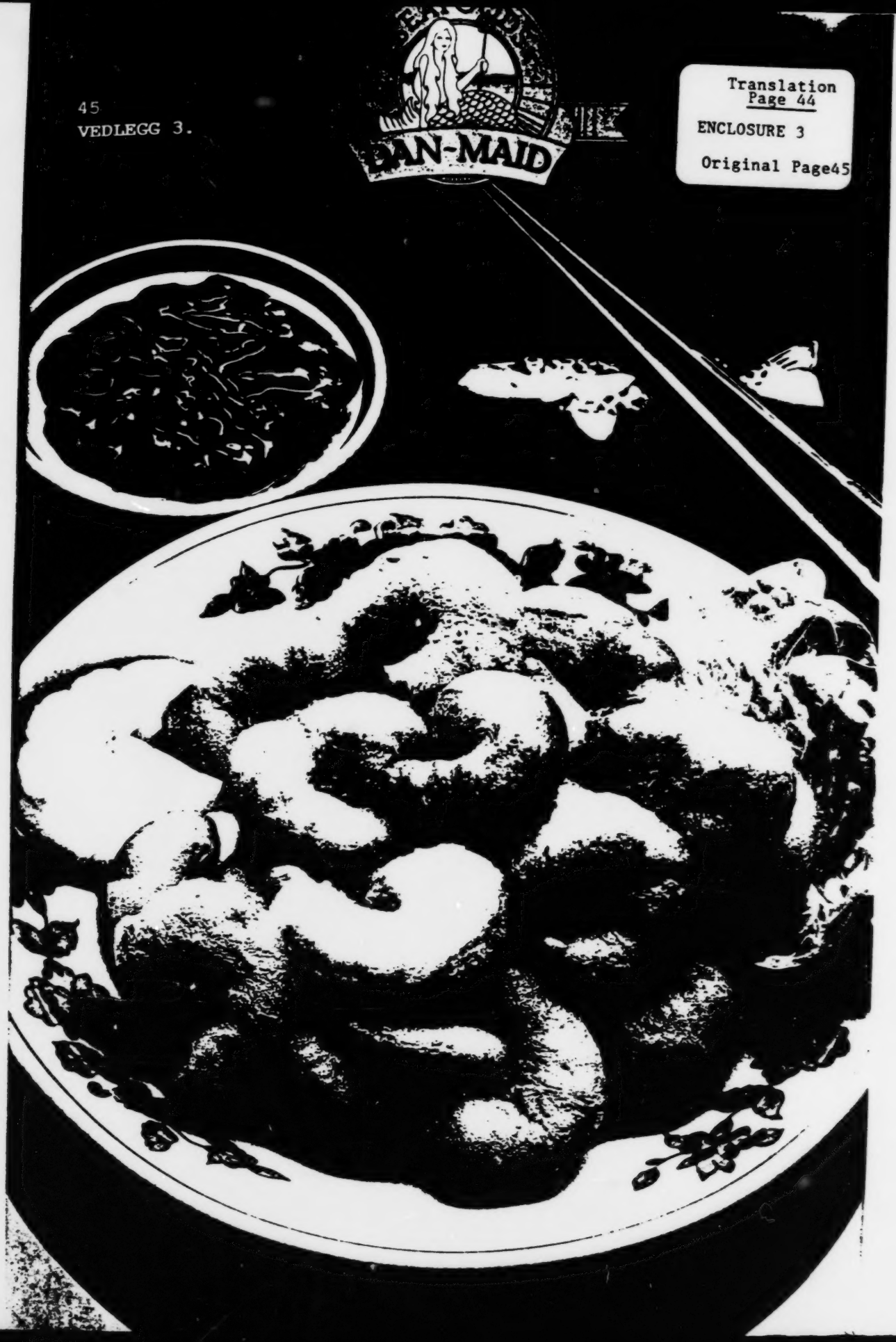

Battercrisp range | Sortiment battercrisp | Produits en beignets | Assortimento in pastella croccante | Surtido rebozado

(IM TEIGMANTEL ZUM FRITTIEREN)

COUNT/LB	STÜCKZAHL/LB	TOTAL/LB	GROSSEZZA/LB	TAMAÑO/LB
40/50 24 x 1lb	24 x 500g	-	-	-

Packs shown are available immediately. Other sizes are available on request.
Die abgebildeten Packungsgrössen sind sofort lieferbar. Weitere Grössen auf Anfrage.
Les paquets montrés sont disponibles dès maintenant. Autres tailles disponibles sur demande.
Le confezioni indicate sono disponibili immediatamente. Altre grossezze sono disponibili su richiesta.
Los paquetes mostrados están listos para entrega inmediata. Se dispone de otros tamaños a petición.

COUNT/LB	U.S.A.	CANADA	NEW ZEALAND	AUSTRALIA	SOUTH AFRICA
40/50	-	-	-	-	24 x 1lb

Packs shown are available immediately. Other sizes are available on request.

Flying Goose Ltd.,
Barrow House, Bishopstrow, Warminster, Wiltshire BA12 9HU, England.
Telephone: (0985) 214565. *Telex:* 449357. *Cables:* Flyingoose Warminster.

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VEDLEGG 3.

Translation
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ENCLOSURE 3

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SEAFOODS
DAN-MAID

Raw Peeled & Cleaned
Raw Headless Shell-On
IQF Prawns for Cooking

No more wasteful bulk thawing! These highest quality prawns are INDIVIDUALLY QUICK FROZEN, making portion controlled preparation quick, easy and economical. Just open the bag and take out the number you need. We've even provided specific cooking times for each size of prawn. So why settle for a chip off the old block when you could be buying DAN-MAID I.Q.F. RAW PRAWNS?

Page 48 **VEDLEGG 3.**
ENCLOSURE 3

Raw Peeled & Cleaned
Raw Headless Shell-On
IQF Prawns for Cooking

INDIVIDUALLY QUICK FROZEN

Versatile

Portion Control

Economical — less waste

HIGHEST QUALITY

Stringent Quality Control at source and throughout processing

Sophisticated processing facilities

EASE OF PREPARATION

Easy to follow instructions, recipe ideas, and specific cooking times for each size.

Raw Peeled & Cleaned	*Raw Headless Shell-On*
26/30 31/35 41/50 61/80	26/30 36/40 51/60 71/90
PACKED 24 x 1 LB	

FLYING GOOSE

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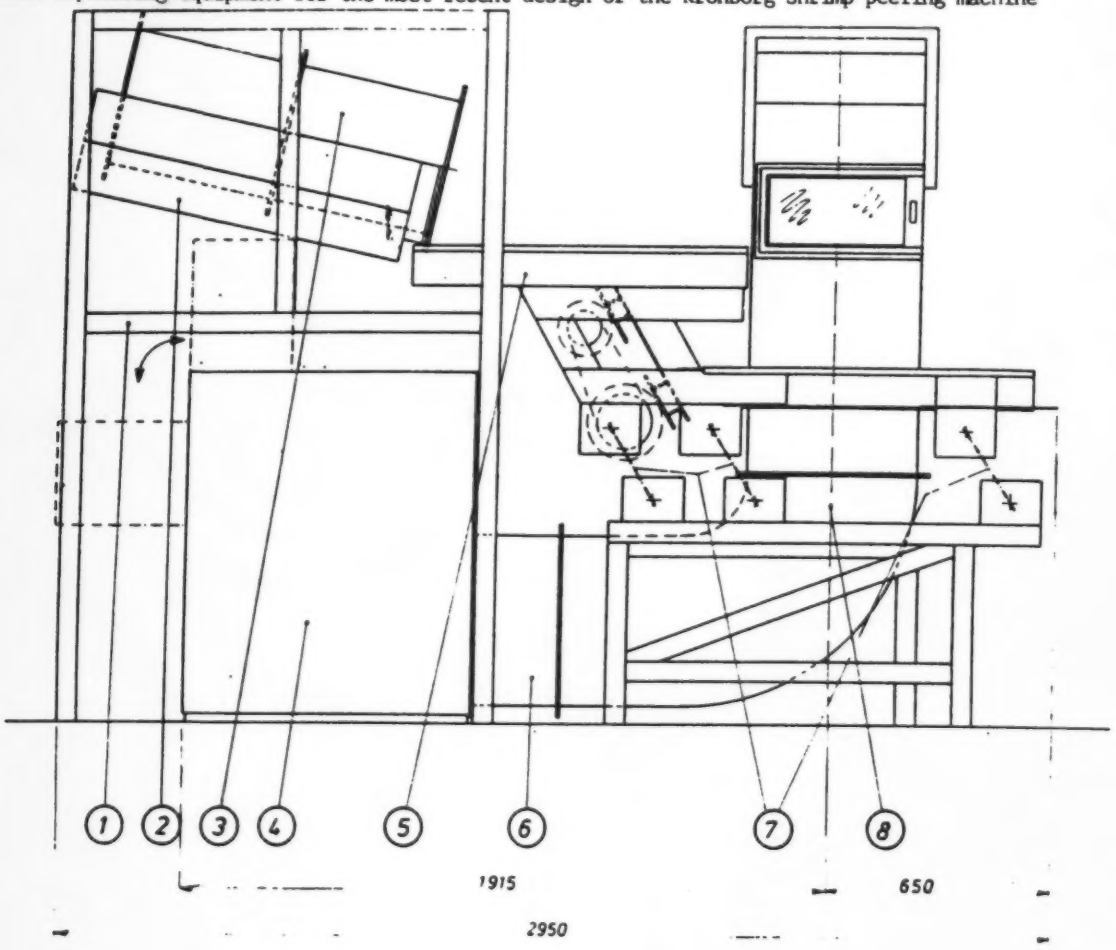
VEDLEGG 4. **Arrangement av skallsepareringsutstyr til den nyeste**
ENCLOSURE 4. **utførelsen av Kronborg rekepillemaskinen.**

Shell separating equipment for the most recent design of the Kronborg shrimp peeling machine



TEGNFORKLARING:
LEGEND

1. Stativ	Frame
2. Avløpsrenne	Drain
3. Våttromle	Wet drum
4. Luftblåser	Air bubbles
5. Vibratorrenne	Vibrator drain
6. Pulsator	Pulsator
7. Svingarm	Swivel arm
8. Skallsepareringskammer	Shell separating chamber

UNEDITED TRANSLATION
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Information seulement

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ISBN 82-7251-194-0

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TRANSLATOR's NOTES

Norwegian term	
Reke	Shrimp or prawn (e.g. deepwater prawn). It was decided to use "shrimp" in the present translation in view of its use in the English title on the cover sheet.
Modning	The traditional translation is ripening, maturing. In the context of the pretreatment of shrimps it was decided to use "curing".
Temperering	The traditional translation is tempering, warming up, taking the chill off.- With a view to distinguishing it from the earlier heating (cooking) stage in the process it was decided to use "temperating".

Table in Enclosure 1 on page 40

All figures in brackets would appear to be standard deviations.